CS Bits and Bytes
Highlighting Innovative Computer Science Research
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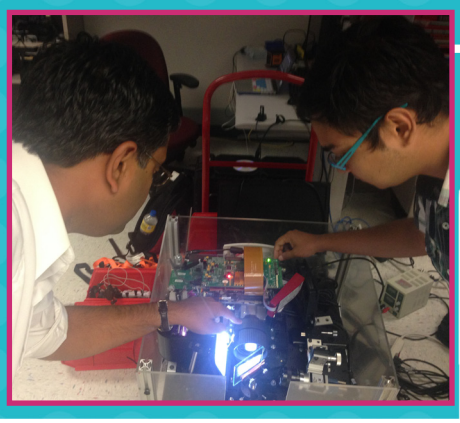
Smart Headlights



Credit: Robotics Institute, Carnegie Mellon University

> The challenge was how... to use the headlight as a flexible programmable I/O device to perform many tasks at once.
>
> Srinivasa Narasimhan
> Carnegie Mellon University

Programmable Headlights Improve Visibility and Reduce Glare

Do you get annoyed when an oncoming car's headlights blind you? New reactive, "smart" headlights can help! The high beams of these headlamps can be used all the time, will react to oncoming drivers by dimming the light so as not to blind the drivers, and can also react to the scene ahead.

The seemingly basic concept of headlampson automobiles is an active area of research, in which computer science plays a key role. Traditionally, computer science has been used to optimize the brightness and anti glare of headlights by simulating different headlamp designs (lamp type/light source) and arrangements (lamp positions, beam aim, and lamp housings). New headlamp technologies aim to improve drivers' visibility, making headlights brighter, adaptable, and now even smart.

These programmed headlights are made possible by a three-stage process. The process begins with an imaging sensor that, like a camera, captures images of the road in front of the vehicle. Second, a processor analyzes those images using algorithms to determine which objects are in front of the car (such as other headlights, pedestrians, road lanes, and even individual drops of precipitation - like rain or snow.) and determines the illumination patterns needed. Finally, a spatial light modulator controls the light, adjusting the light beam by separating the beam into a million tiny light beams that can be independently controlled.

One challenge of these smart headlights was decreasing the latency, or processing time, so that the driver doesn't see any flicker of

the headlight, which would be distracting. Researcher Dr. Srinivasa Narasimhan and

his team at Carnegie Mellon University used parallel processing to go through the three stages simultaneously. Instead of waiting for each stage to finish before the next stage can begin, the stages can run concurrently, allowing the programmable headlights to have a reaction time of less than two milliseconds. As a result, the headlight adapts to changing visual scenes almost instantly.

Who does this stuff ?

Srinivasa Narasimhan is associate professor of robotics in the Illumination & Imaging Laboratory at the Robotics Institute of Carnegie Mellon University. His research group focuses on novel techniques for imaging, illumination, and light transport to enable applications in vision, graphics, robotics, and medical imaging. In addition to co-inventing programmable headlights, Dr. Narasimhan has also co-invented the Aqualux 3D display, Assorted Pixels, motion-aware cameras, and low-power outdoor-Kinect, and he has received numerous awards for his work.

Dr. Narasimhan is motivated by "using the amazing opportunities at Carnegie Mellon University to tackle big questions that can improve people's lives." In his spare time, he is learning a lot about dinosaurs alongside his son.

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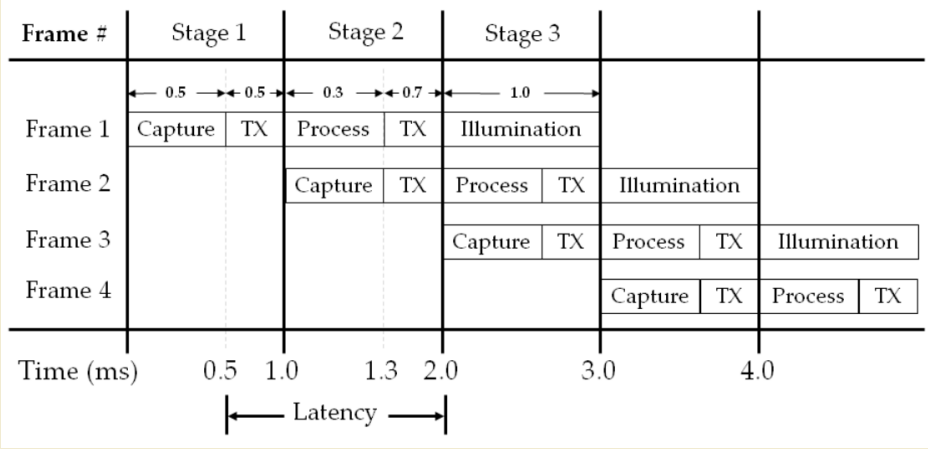

The table to the right (from http://www.cs.cmu.edu/~ILIM/projects/IL/smartHeadlight/ media_v3/etc/TNCCRKN-ECCV14.pdf) is a timing diagram of the three-stage process for the programmable headlights, measured in milliseconds, or a thousandth of a second. Capture = camera exposure, TX = data transfer, Process = image analysis, Illumination = directing light beams, and Latency is the time between capturing an image and adjusting the illumination.

Try this Out

Discuss the following:

1. In this example, each stage took the exact same time to complete. What would happen if the processing stage took twice as long? How would you adjust the illumination stage to prevent flickering?
2. Discuss how the use of parallel processing can speed up work and decrease system latency.
3. What factors can contribute to latency in the programmable headlights system? (Need a hint? See Section 4 of the paper linked above.)

Learn More

Watch the programmable automotive headlight in action!
http://www.cs.cmu.edu/~ILIM/projects/IL/smartHeadlight/

Read more about the Illumination and Imaging Laboratory, which is dedicated to the study of light transport and the development of novel illumination and imaging techniques.
http://www.cs.cmu.edu/~ILIM/

Want to know more about Srinivasa Narasimhan's research?
http://www.cs.cmu.edu/~srinivas/

Research by the U.S. Department of Transportation's National Highway Traffic Safety Administion aims to make vehicles safe. Read about their studies on headlights.
http://www.nhtsa.gov/Research/Human+Factors/Headlighting

About

CS Bits & Bytes is a biweekly newsletter highlighting innovative computer science research. It is our hope that you will use CS Bits & Bytes to engage in the multi-faceted world of computer science to become not just a user, but also a creator of technology. Please visit our website at: www.nsf.gov/cise/csbytes.

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